COMMENT ON CHERNAVSKAYA'S PAPER "DOUBLE PHASE TRANSITION MODEL AND THE PROBLEM OF ENTROPY AND BARYON NUMBER CONSERVATION" hep-ph/9701265

V. J. Menon [1] and B. K. Patra[2†]

[1]*Department of Physics, Banaras Hindu University, Varanasi 221 005, India*

[2]*Institute of Physics, Sachivalaya Marg, Bhubaneswar 751 005, India*

1 Introduction

In the standard construction of a first-order equilibrium phase transition via the Gibbs criteria from a quark-gluon plasma (QGP) to a hot and dense hadron gas (HG), the appearance of a discontinuity in the entropy per baryon ratio (s/n) makes the phase transition at fixed temperature T and fixed chemical potential μ irreversible. Recently several papers have been addressed to the question of conserving the entropy per baryon s/n across the phase boundary. Leonidov et al. [1] have proposed a bag model equation of state (EOS) for the QGP consisting of massless, free gas of quarks and gluons using a (μ, T) dependent bag constant $B(\mu, T)$ in an isentropic equilibrium phase transition from a QGP to the HG at a constant T and μ. Later Patra and Singh [2] have extended this idea to remedy some anomalous behaviour of such a bag constant $B(\mu, T)$ through the inclusion of perturbative QCD corrections in the EOS for QGP. They have also explored the consequences of such a bag constant on the deconfining phase transition in the relativistic heavy-ion collisions as well as in the early Universe case [3].

The above mentioned analysis refers only to the stationary systems. But in the context of modern experiments on ultrarelativistic heavy-ion collisions, the dynamical evolution of the system within the framework of hydrodynamical models has to be incorporated

---

†E-mail: bkpatra@iopb.stpbh.soft.net

also. Recently Chernavskaya [4] have suggested a double phase transition model via an intermediate phase containing massive constituent quarks and pions. He claimed that only the continuity condition in s/n ratio does not provide equilibrium character of first-order transition in dynamically evolving systems as for all equilibrium processes, but enthalpy of the system as well. Subsequently he has also criticized the work of Ref. 1 and 2 on the ground of twin constraints arising from Gibbs - Duham equilibrium relation [5] and enthalpy conservation [6] for an evolving system. The aim of the present note is to logically counter both these criticisms below.

2   Gibbs - Duham Relation

Ref.[4] suggests that if ϵ is the energy density and p the pressure then form-invariance of the relation

$$\epsilon + p - \mu n = sT \tag{1}$$

imposes the condition

$$\mu \ \frac{\partial B}{\partial \mu} = -T \ \frac{\partial B}{\partial T} \tag{2}$$

We comment that eq.(2) is untenable due to two reason. Firstly, it would imply that B, instead of being a function of two independent variables μ and T, will depend only on the single variable $\mu/$T as can be verified by direct differentiation. Secondly, eq.(2) would make it impossible to apply the iterative analytical procedure [1,2] of solving the basic partial differential equation based on s/n in the extreme regions $\mu \to 0$, T $\to \infty$ as well as $\mu \to \infty$, T $\to 0$. This would imply a conflict with the QCD sum rule results [7].

3 Enthalpy Condition

Ref.[4] mentions that, if $\omega = \epsilon + P$ is the enthalpy density, then for an evolving hydrodynamic system containing the mixed phase of the QGP and hadronic gas, the conservation of enthalpy per baryon ω/n gives an additional constraint. We comment that this constraint is redundant, i.e., does not give a new information. This is so because even if the system is evolving with time, we can sit in the local comoving frame where the relation (1) is expected to hold. Then

$$\frac{\omega}{n} = \frac{(\epsilon + P)}{n} = T \ \frac{s}{n} + \mu \tag{3}$$

implying that, for any given T and μ, the conservations of ω/n and s/n are equivalent.

References

[1] A. Leonidov, K. Redlich, H. Satz, E. Suhonen and G. Weber, Phys. Rev. D **50** (1994) 4657.

[2] B. K. Patra and C. P. Singh, Phys. Rev. D **54** (1997) 3551 ; Z. Phys. C **74** (1997) 699.

[3] B. K. Patra and C. P. Singh, Phys. Lett. B **427** (1998) 241.

[4] O. D. Chernavskaya, hep-ph/9701265

[5] Landau, L. D. and E. M. Lifshitz, Statistical Physics (Pergamon, Oxford) (1958).

[6] Appendix of Ref.4

[7] J. Dey and M. Dey, Phys. Lett. **176** (1986) 469.